2. WASTE RETRIEVAL ALTERNATIVES

The three retrieval alternatives are based on the following selection criteria: cross contamination, contamination spread, implementability, and schedule risk (INEEL 2003b). All three alternatives use a large, open primary confinement with a secondary confinement and remotely operated equipment. The three alternatives are listed and summarized below:

- Backhoe–Crane Method (Alternative 1). This alternative uses a remotely controlled backhoe, overhead crane, and automatic guided vehicle (AGV) to excavate the pit. Overburden and underburden are excavated and loaded into hoppers by the above grade backhoe and transferred by the crane and AGV to designated locations. Waste material is loaded into boxes by the above grade backhoe, which are moved to the transfer location by the crane and transported to the characterization and treatment area by an AGV. Characterized and treated waste is packaged in boxes, grouted, and replaced in the pit by the AGV and crane. Underburden and overburden are backfilled by the crane and leveled and compacted by a remote compactor.
- Front-End Loader–Backhoe Method (Alternative 2). This alternative uses a backhoe to excavate and pile the overburden and underburden, and a front-end loader to excavate the waste seam and transport the backhoe soil piles to designated locations. The front-end loader or an AGV can transport waste to the treatment and characterization facility. The backhoe may also assist the loader during waste excavation as needed. Characterized and treated waste is packaged and grouted in boxes and replaced in the pit with a forklift/loader. Underburden and overburden are replaced, leveled, and compacted by the loader.
- Backhoe–Forklift Method (Alternative 3). This alternative uses a backhoe to excavate pit materials into boxes and a forklift/AGV combination to transport the excavated material to designated locations. Characterized and treated waste is packaged and grouted in boxes and replaced in the pit by the Forklift/Loader. Underburden and overburden are backfilled by the AGV/forklift and leveled and compacted by a remote compactor.

Alternatives 1 and 3 use an above-grade approach, which excavates the site from the top of the overburden to keep the equipment (except for the excavator bucket) out of the waste material. Alternative 2 uses a below-grade approach, which excavates the site from the bottom of the waste material seam. Each of these methods is further subdivided into four operations: overburden removal, waste excavation, underburden excavation, and backfill and closure. Each operation involves the excavation or backfilling of the pit through a series of passes that remove or replace specified layers of material illustrated in Figure 3. Figure 4 summarizes the process flow (material in and out of the pit). The total estimated material volumes and flow rates for each alternative are compared in the table of Figure 4.

Appendix A presents a graphic comparison that summarizes the three retrieval alternatives with respect to how the pit is excavated and backfilled. Appendix A also provides logic diagrams identifying the implementation of the three alternatives.

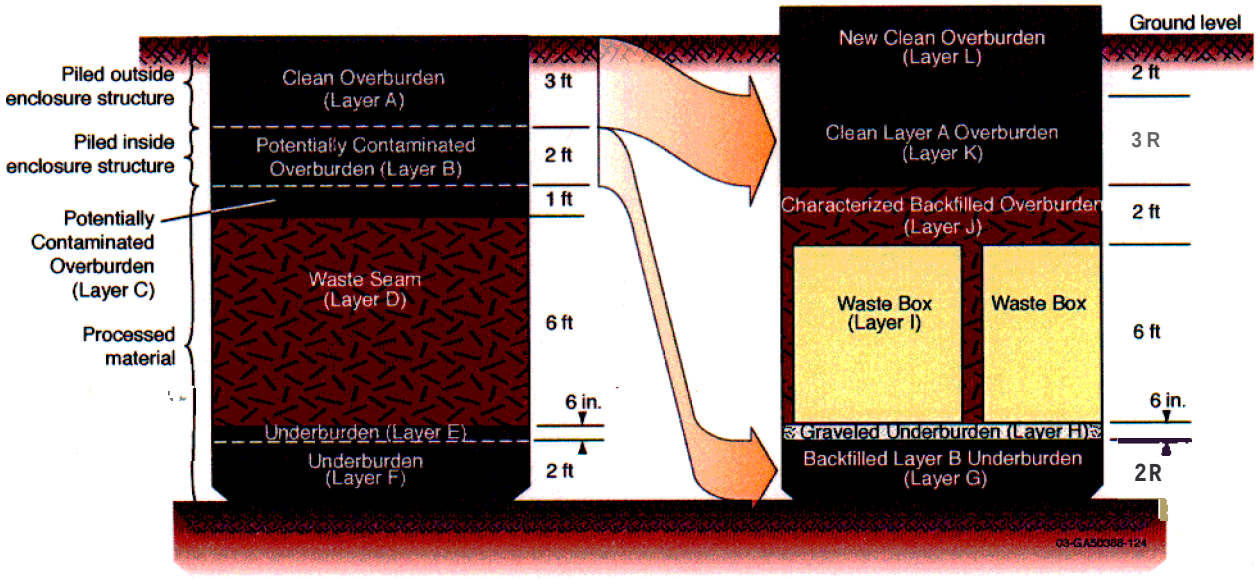
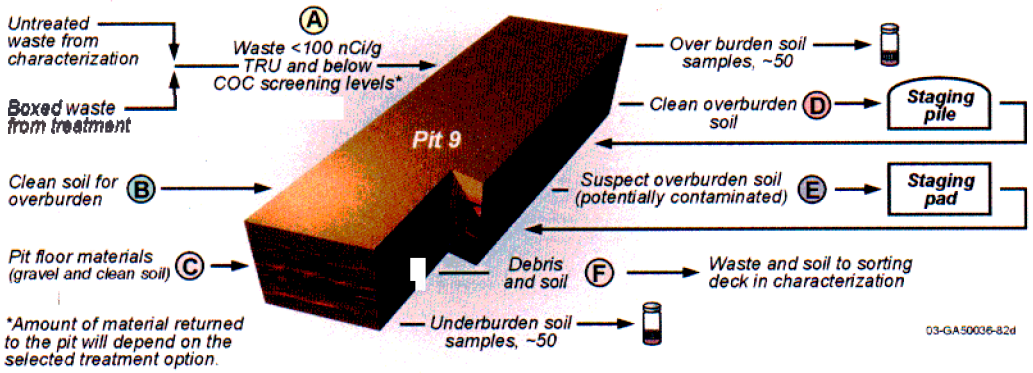


Figure 3. Cross-sectional view of the excavation site illustrating the various layers (A–L) of material removed from the pit (left side) and backfilled into the pit (right side). See the detail summary in Figure A-1 (Appendix A).



Alternative →	1	2	3
A Cubic feet total	250,000	250,000	250,000
B Cubic feet total	90,000	50,000	90,000
C Cubic feet total	25,000	50,000	25,000
D Cubic feet per day Cubic feet total	1,200 135,000	2,150 135,000	1,200 135,000
E Cubic feet per day Cubic feet total	1,200 90,000	2,150 90,000	1,200 50,000
F Cubic feet per day Cubic feet total	1,100 435,000	1,100 435,000	1,100 435,000

Figure 4. Comparison of the material flow in and out of Pit 9 for the three alternatives.

2.1 Backhoe–Crane Method (Alternative 1)

The Backhoe–Crane Method (Alternative 1), which meets the criteria for above-grade retrieval operations, uses a diesel-powered backhoe located on the surface, and an electrically powered overhead bridge crane to excavate and backfill Pit 9. A series of **8** passes are performed during the excavation and backfilling process to accomplish this alternative. Together with Figure **3** and Figure A-1, this section provides an overview of this alternative, but it does not identify all aspects of the process, such as the overburden soil core sampling and decontamination methods to be used during retrieval operations.

2.1.1 Overburden Removal

NOTE: Pass 1 will be used as a cold test of remote operations and Pass 2 will begin hot operations.

Pass 1. Moving south-to-north across the entire pit, the backhoe excavates and loads the top **3** ft of overburden (Layer **A')** into standard soil hoppers (see Figure 5). The crane, with a hopper handler attached to the hook, places the loaded soil hopper on an electrically powered automatic guided vehicle (AGV). The AGV delivers the hopper to a clean overburden area located outside of the confinement structure where it is dumped by a forklift. A front-end loader then piles the clean overburden, which will receive appropriate design controls to limit wind and water erosion. The forklift and front-end loader, which are used outside the confinement structure only, will be rentals or part of the INEEL equipment pool. The AGV and crane return the empty hopper to the backhoe. Pass 1 is completed before Pass 2 begins.

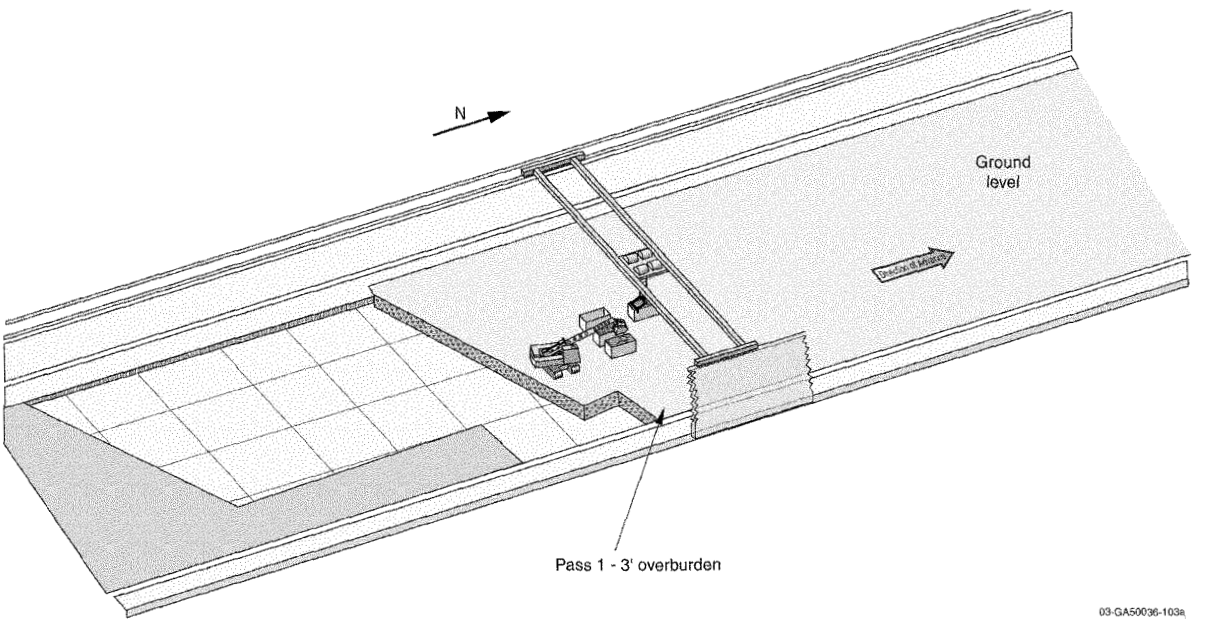


Figure 5. The backhoe excavates the top *3* ft of overburden from the pit moving south-to-north.

[2] Reference Figures 3 and A-1 for layer placement within the identified retrieval process

Pass 2. Moving south-to-north across the entire pit, the backhoe excavates and loads the next 2 ft of overburden (Layer B) into the hoppers (see Figure 6). This soil is assumed to be potentially contaminated. The overhead crane delivers each hopper to the designated overburden staging area inside the retrieval enclosure, dumps it, and returns it to the backhoe to be refilled. Pass 2 is completed before Pass ***3*** begins.

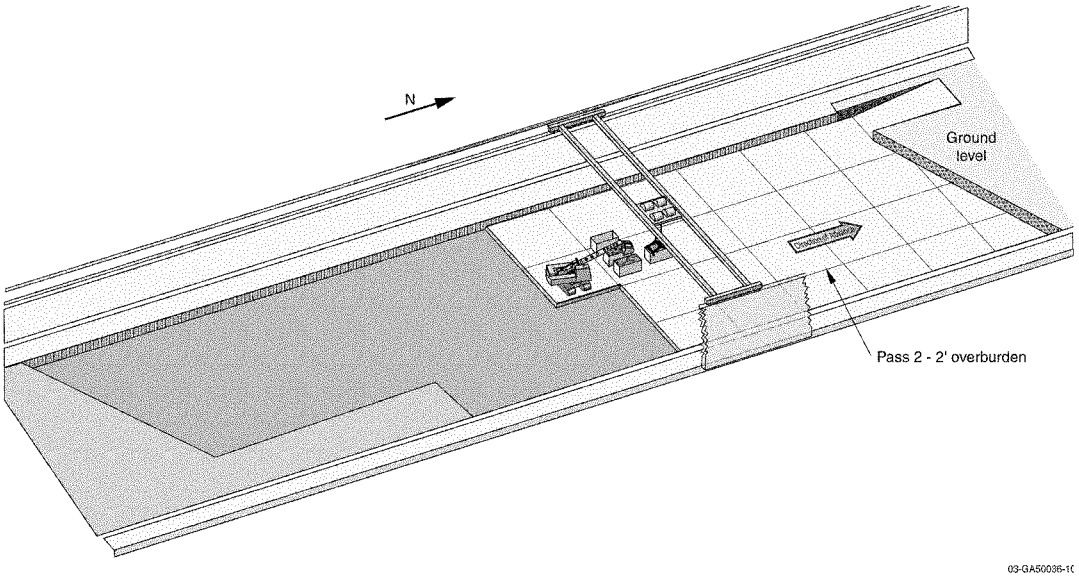


Figure 6. The backhoe excavates the next 2 ft of overburden from the pit moving south-to-north.

2.1.2 Waste Excavation

Pass 3. Moving south-to-north across the entire pit, the backhoe excavates and loads the remaining 1 ft of overburden (Layer C), 6 ft of waste material and 6 in. of underburden (Layers D and E), and 2 ft of underburden (Layer F) into the 5 x 10 x 5-ft-high boxes (see Figure 7).

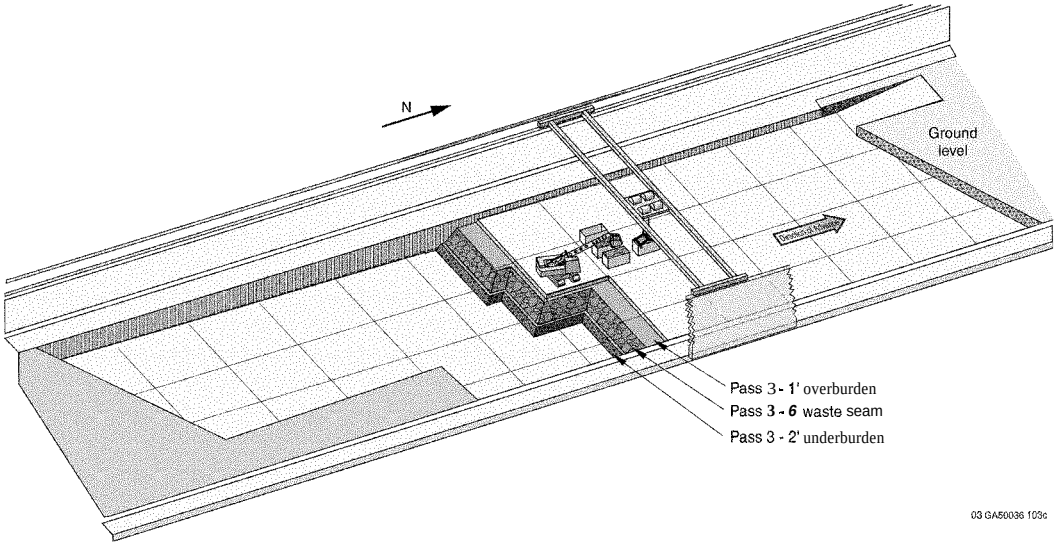


Figure 7. The backhoe excavates the waste seam and underburden from the pit moving south-to-north.

The backhoe performs the following 3-part process at each working location to excavate dig face material before moving to the next working location, thereby advancing the excavation of all four layers across the pit in one pass:

Part 1 The backhoe excavates the remaining 1-ft of overburden (Layer C), segregates it from the waste, and places it in a box. All the soil between the backhoe and the dig face is excavated before starting Part 2.

Part 2 The backhoe excavates the 6-ft-thick seam of waste (Layer D) plus about 6 in. of the underburden (Layer E) and loads it into a separate box. All the material between the backhoe and the dig face is excavated before starting Part 3, except for a ledge left at the top of Layer D to keep the soil in Layer C from falling onto the underburden (Layer F). Radiation surveys are performed at the dig face to find high-radiation sources. If found, this material will be placed in a separate container and grouted. High radiation objects too large for a container or any object too large for treatment will be stabilized in place or moved to a new pit location and stabilized.

Part 3 The backhoe excavates 2 ft of the underburden (Layer F) and loads it into a third box. All of the underburden between the backhoe and dig face is excavated before moving to a new work location; however, a ledge is left at the top of Layer F so that waste items from Layer D do not fall onto the exposed surface below the excavated underburden.

When a box is full, the overhead crane places it on the AGV at the north end of the pit. The AGV delivers the box directly to the sorting deck, where the contents are dumped, sorted, and processed through characterization. The AGV and crane return the empty box to the backhoe. All four layers are excavated in one work location before the backhoe is moved to the next. Excavation proceeds laterally across the pit, and advances through the dig face from south-to-north. Pass 3 will be worked in parallel with Pass 4 once enough underburden has been removed to allow Pass 4 to begin.

2.1.3 Backfill and Closure

Pass 4. Pass 4 will begin when enough underburden has been removed in Pass 3 to avoid conflicts with excavation. Moving from south-to-north, the backhoe and crane backfill the pit with 2 ft of potentially contaminated soil from the inside overburden staging area (Layer G) and gravel (Layer H) (see Figure **8).** Layer G is composed of soil from Layer B (see Figure 3). The backhoe loads the soil into the hopper. The overhead crane carries the hopper across the pit and dumps it where needed. A small remote-controlled diesel-powered compactor with a blade levels and compacts the soil to a depth of 2-ft. When the underburden is compacted, a 6-in.-thick layer of gravel (Layer H) is placed over the new underburden. The gravel is loaded into the hopper through a double-gated chute that penetrates the containment. The overhead crane carries the hopper across the pit and dumps it where needed. The compactor is used to level and compact the gravel. Pass 5 begins when enough of the graveled floor has been compacted to allow placement of the boxes without interfering with Passes 3 and 4.

Pass 5. Moving from south-to-north, the overhead crane backfills the pit with 5 x 5 x 6-ft-high waste boxes (Layer I) filled with repackaged and grouted waste from treatment (see Figure **8).** This pass is performed in parallel with Passes 3 and 4. The AGV delivers the waste boxes from the treatment area to the north end of the pit. The overhead crane places the boxes on top of the finished gravel floor. Pass 5 is completed before Pass 6 begins. The containment building and equipment may also be decontaminated at this time to minimize contamination of newly placed overburden layers.

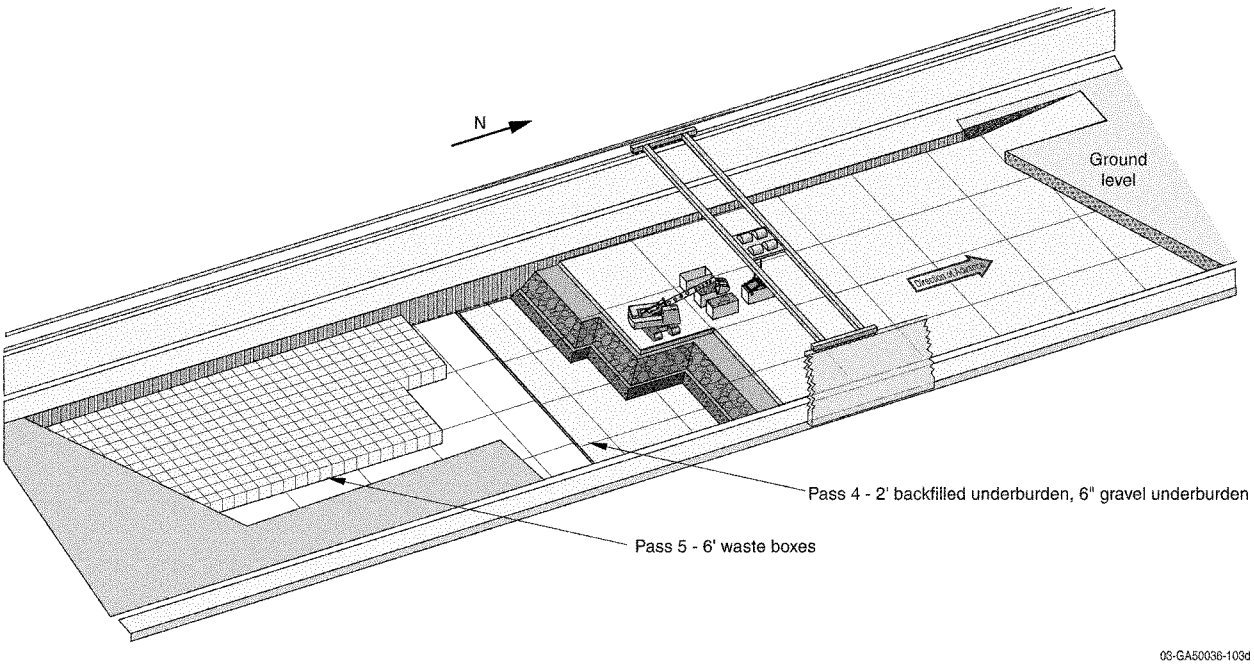


Figure 8. The backhoe and crane backfill the pit with 2 ft of overburden, 6 in. of gravel, and waste boxes moving south-to-north.

Pass 6. Using a yet to be defined sequence of operation, the hoppers, AGV, and overhead crane backfill over the boxes with a 2-ft-thick layer of characterized soil (Layer J) from treatment (see Figure 9). A small remotely controlled compactor is used to level and compact the soil. Pass 6 is completed before Pass 7 begins.

Pass 7. Using a yet to be defined sequence of operation, the soil hopper and crane backfill the entire pit with a 3-ft-thick layer (Layer K) of clean overburden brought in from the outside overburden pile; Layer K is composed of soil from Layer A (see Figure 9). This soil is loaded into the hopper via a chute that enters the building through airlock doors. The small remotely controlled compactor is used to level and compact the backfill. This operation may be done in 8-in.-thick intervals with building and equipment decontamination at each interval to promote successively cleaner levels of overburden. Pass 7 is completed before beginning Pass 8 begins.

Pass 8. After confinement building decontamination or disassembly, a clean front-end loader backfills the pit with 2 ft of clean soil (Layer L) obtained from outside the pit area (see Figure 9). This brings the finished elevation to 1 ft above the original grade. Pass 8 completes backfill and closure operations for the Backhoe–Crane Method.

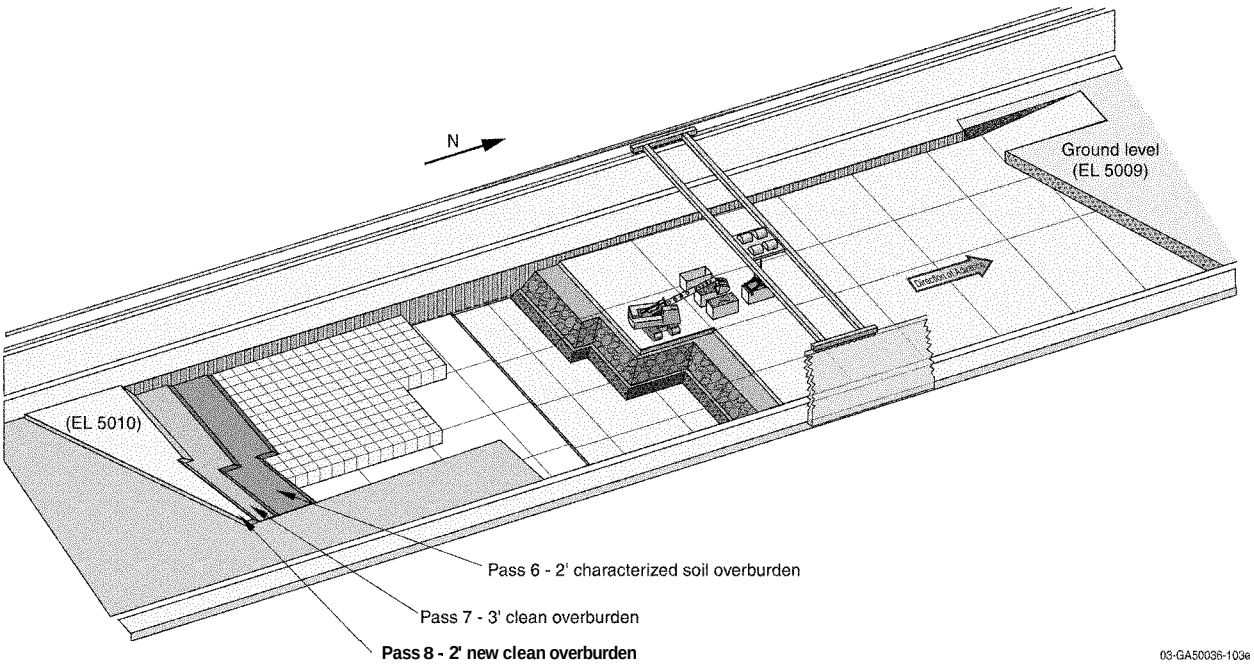


Figure 9. The backhoe and crane backfill the pit with 2 ft of characterized soil, 3 ft of clean overburden, and 2 ft of new clean overburden moving south-to-north.

2.2 Front-End Loader–Backhoe Method (Alternative 2)

The Front-End Loader–Backhoe Method (Alternative 2), which meets the criteria for below-grade retrieval operations, uses a diesel-powered front-end loader and a diesel-powered backhoe to excavate and backfill Pit 9. A series of 9 passes are performed during the excavation and backfilling process to accomplish this alternative. Although this section does not identify all aspects of the process, such as the decontamination methodologies that will be used during retrieval operations, together with Figure 3 and Figure A-1, it gives an overview of this alternative.

The diesel-powered, remotely operated front-end loader has an interchangeable bucket and forks that can be used for different hnctions. Thus, the terms front-end loader, loader, and forklift/loader refer to the same machine.

2.2.1 Overburden Removal

NOTE: Pass 1 will be used as a cold test of remote operations and Pass 2 will begin hot operations.

Pass 1. Moving from north-to-south, the front-end loader removes the top 3 ft of overburden (Layer A) from entire pit and piles it outside the confinement area in a designated location (see Figure 10). Pass 1 is completed before Pass 2 begins.

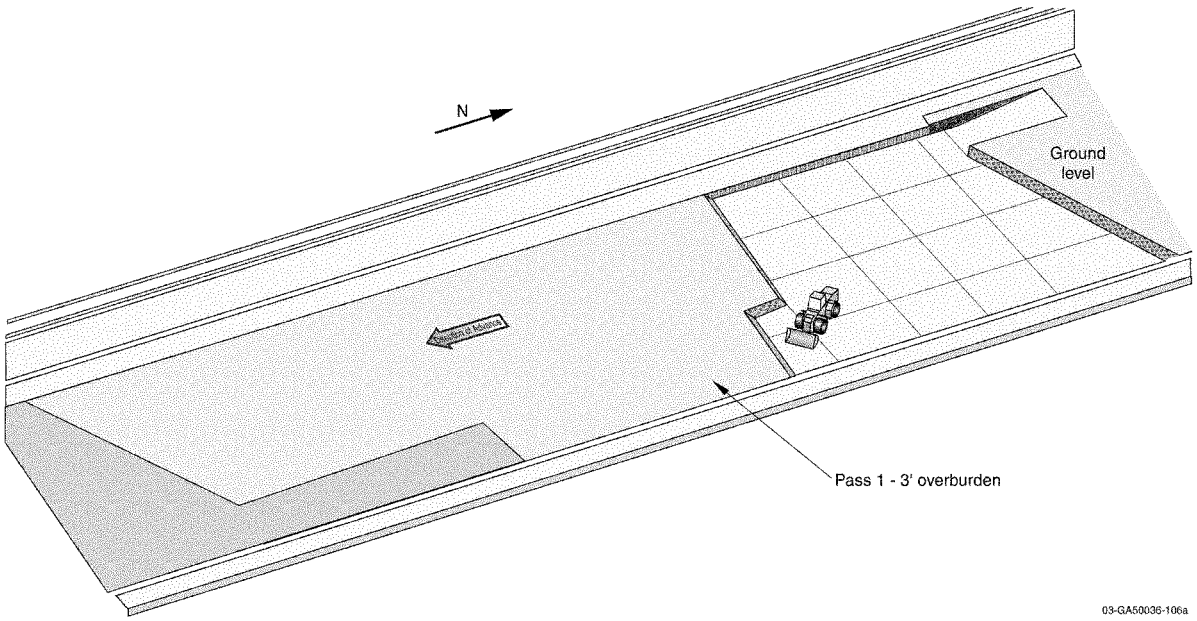


Figure 10. The front-end loader excavates the top *3* ft of overburden from north-to-south

Pass 2. Moving back from south-to-north, the backhoe selectively excavates and piles the next 2 ft of overburden (Layer B) across the entire pit (see Figure 11). The front-end loader scoops and carries this soil, assumed to be potentially contaminated, directly to an overburden staging area inside the enclosure. Layer 2 is completed before Pass *3* begins.

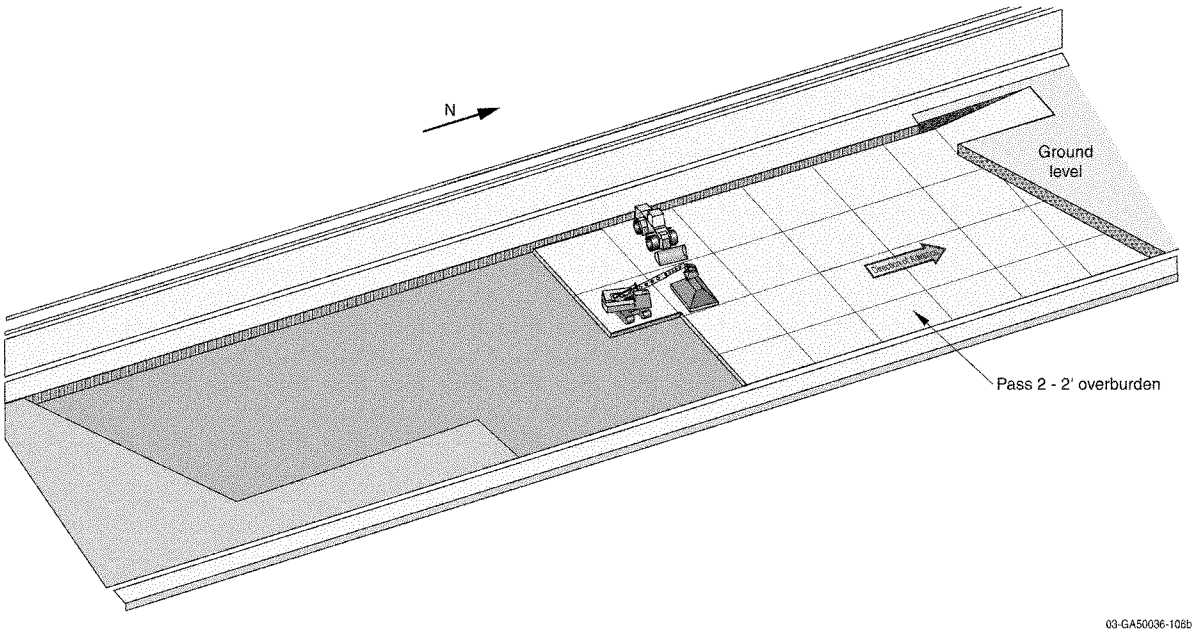


Figure 11. The backhoe and front-end loader selectively excavate the next 2 ft of overburden from the pit moving south-to north.

2.2.2 Waste Excavation

Pass 3. Moving north-to-south, the backhoe and loader simultaneously remove Layers C, D, and E (see Figure 12). The backhoe works on top of Layer C (Part 1 below) while the loader excavates from the top to 6 in. below the waste seam (Layers D and E) (Part 2 below).

Part 1. Working from the top of Layer C, the backhoe excavates the remaining 1 ft of overburden (Layer C) and piles it on the exposed underburden. The loader scoops up the pile and delivers it directly to the sorting deck for characterization. The backhoe excavates all the overburden between it and the dig face before moving to the next work location. To keep the overburden segregated from the waste, the front-end loader removes the overburden before excavating the waste in Part 2.

Part 2. Working at the bottom of the waste, after the backhoe has cleared an area of Layer C, the loader excavates the 6-ft-thick seam of waste (Layer D) plus about 6 in. of the underburden (Layer E) and carries it directly to the sorting deck for characterization. Radiation surveys are performed at the dig face to detect high radiation sources. If found, these sources are placed in containers and grouted. Objects too large for a container or treatment are stabilized in place or moved to a dedicated pit location and stabilized. The backhoe is used to help with this operation, if needed. As the excavation advances, the loader also spreads gravel on the main traffic areas of the pit floor to harden the surface for wheel traffic. The gravel also provides a medium to help remove and collect pit material from the wheels of the loader, thus limiting the spread of contamination. Pass *3* is worked in parallel with Pass 4, once Pass 4 work begins.

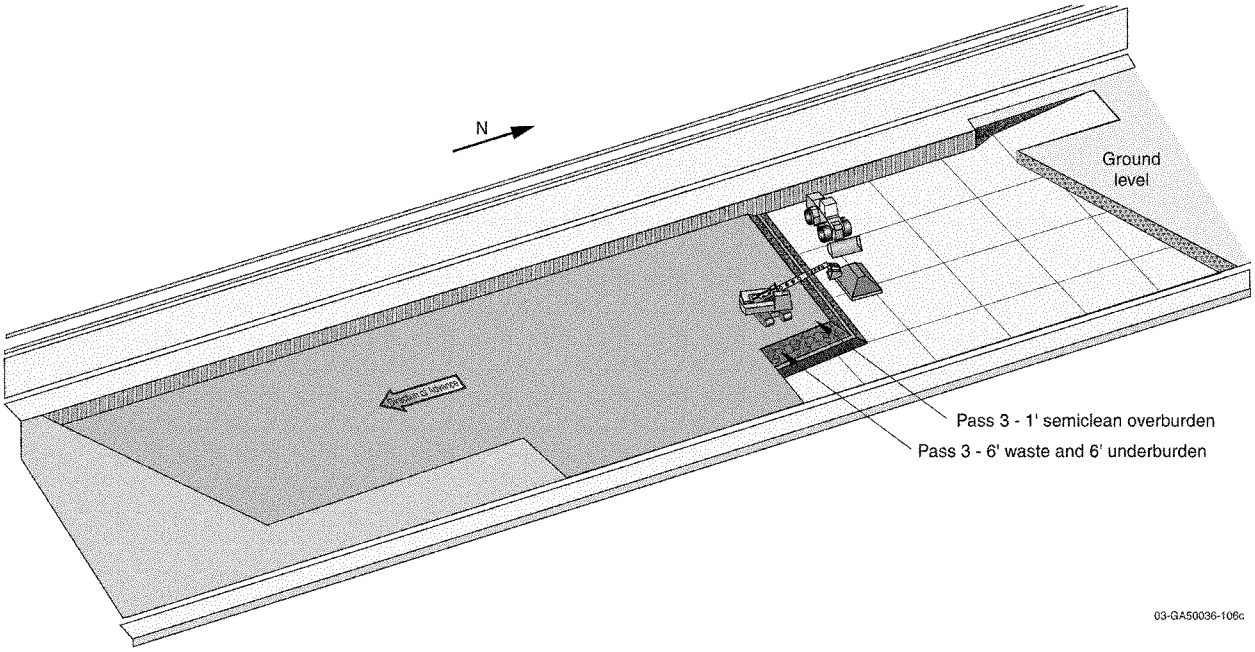


Figure 12. The front-end loader excavates the waste seam from the pit moving north-to-south

Pass 4. When enough waste material has been removed in Pass 3 for underburden excavation to begin, the backhoe and/or the front-end loader will build a ramp over the waste seam from available soil, and the backhoe will move down to the underburden (see Figure 13). Moving north-to-south and working in parallel with Pass 3, the backhoe excavates and piles the remaining 2-ft of underburden (Layer F). The front-end loader scoops up the piled underburden and carries it directly to the sorting deck.

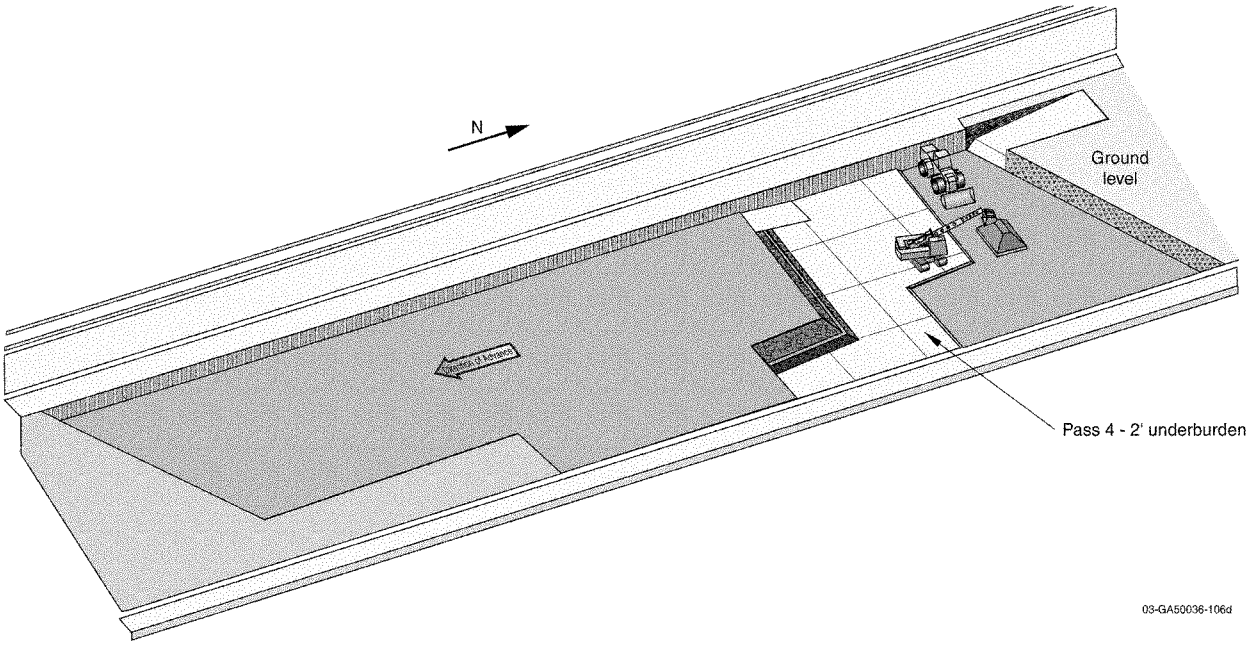


Figure 13. The backhoe and front-end loader excavate the remaining 2 ft of underburden from the pit moving north-to-south.

2.2.3 Backfill and Closure

Pass 5. Pass 5 begins when enough underburden has been removed in Pass 4 to avoid interference with the ongoing excavation. Moving from north-to-south, the front-end loader backfills, levels, and compacts the pit with 2-ft of underburden (Layers G) using the soil from the overburden staging area deposited in Pass 2 (see Figure 14); Layer G is composed of soil from Layer B (see Figure 3). The front-end loader then obtains gravel through an airlock chute that penetrates the containment, and places and compacts it in a 6-in.-thick layer (Layer H) atop the underburden. Pass 5 is performed in parallel with Pass 3 and 4.

Pass 6. Pass 6 begins when enough of the graveled floor has been prepared to avoid interfering with the underburden placement. Moving from north-to-south, the front-end loader backfills the pit with 5 x 5 x 6-ft-high waste boxes (Layer I) containing repackaged and grouted waste from treatment (see Figure 14). This pass is performed in parallel with Passes 3, 4, and 5. Pass 6 is completed before Pass 7 begins. The containment building and equipment may also be decontaminated at this time to minimize contamination of newly placed overburden layers.

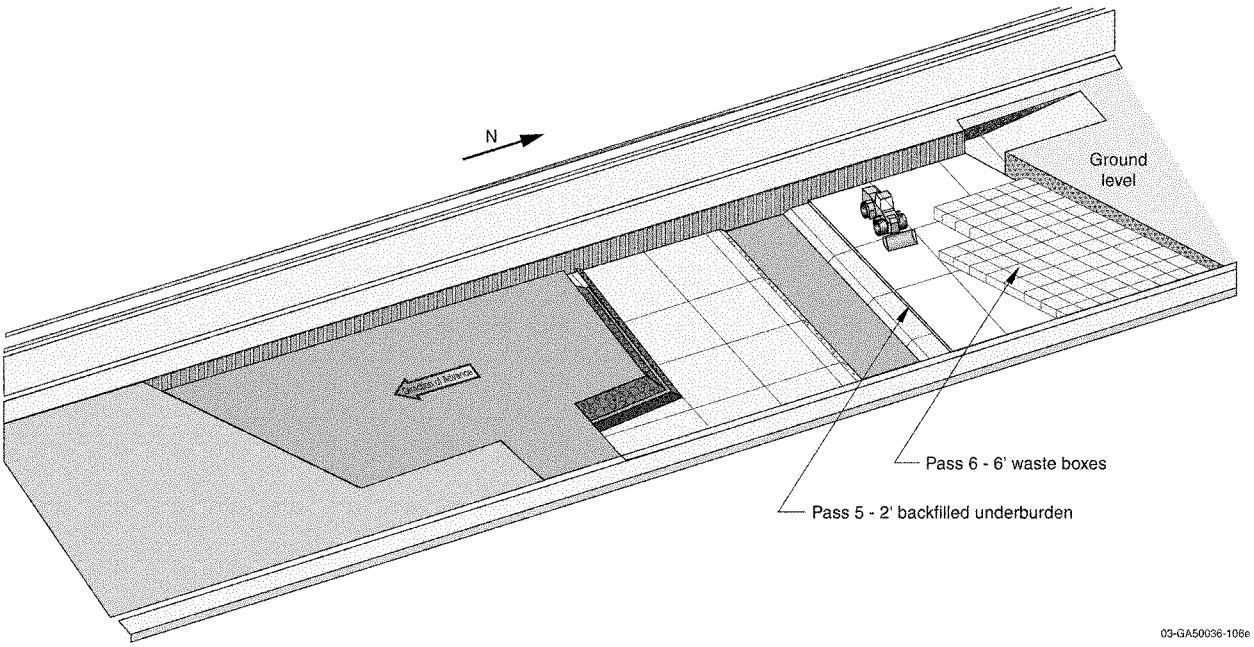


Figure 14. The front-end loader backfills the pit with 2 ft of underburden and 6 in. of gravel moving north-to-south.

Pass 7. Using a yet to be defined sequence of operation, the front-end loader places, levels, and compacts a 2-ft-thick layer of characterized soil (Layer J) from treatment (see Figure 15). Pass 7 is completed before Pass 8 begins.

Pass 8. The front-end loader backfills and compacts the entire pit with a 3-ft-thick layer (Layer K) of clean overburden obtained from the outside overburden pile (see Figure 15); Layer K is composed of soil from Layer A (see Figure 3). This soil is loaded into the hopper via a chute that enters the building through airlock doors. This operation may be done in 8-in.-thick intervals with building and equipment decontamination at each interval to promote successively cleaner levels of overburden. Pass 8 is completed before Pass 9 begins.

Pass 9. After confinement building decontamination or disassembly, a clean front-end loader backfills the pit with 2 ft of clean soil (Layer L) obtained from outside the pit area (see Figure 15). This brings the finished elevation to 1 ft above the original grade. Pass 9 completes backfill and closure operations for the Front-End Loader–Backhoe Method.

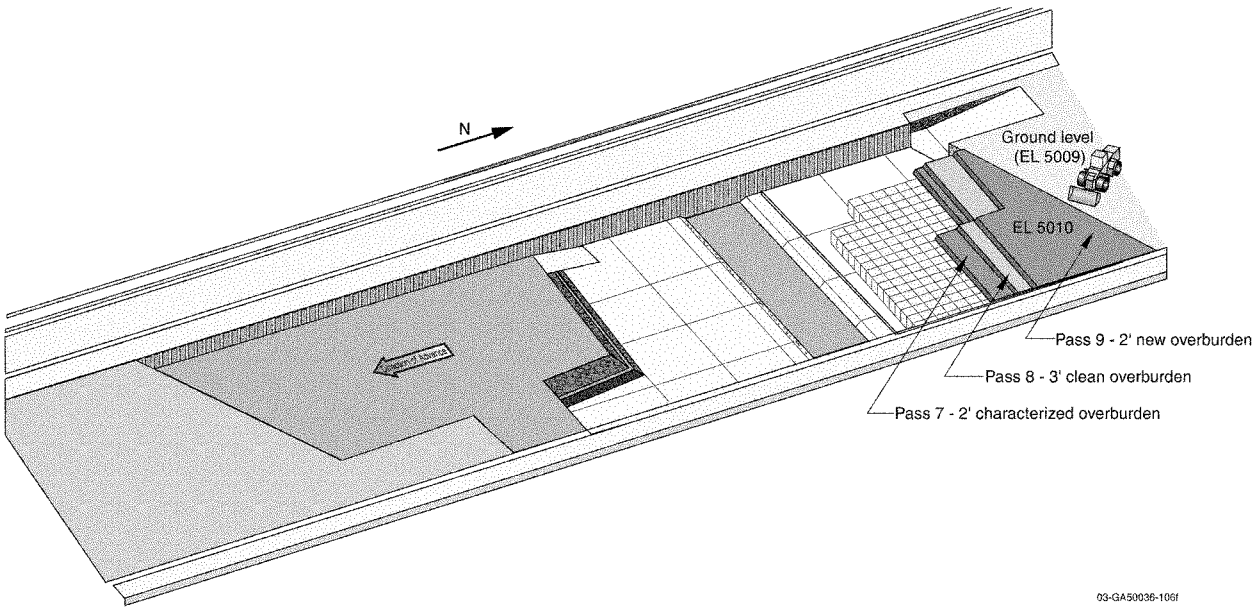


Figure 15. The front-end loader backfills the pit with 2 ft of characterized overburden, *3* ft of clean overburden, and 2 ft of new overburden; direction of movement is yet to be determined.

2.3 Backhoe-Forklift Method (Alternative 3)

The Backhoe-Forklift Method (Alternative *3),* which meets the criteria for above-grade retrieval operations, uses a diesel-powered, remotely operated backhoe located on the surface and a diesel-powered, remotely operated forklift/loader to excavate and backfill Pit 9. A series of 8 passes are performed during the excavation and backfilling process to accomplish this alternative. Although this section does not identify all aspects of the process, such as the decontamination methodologies that will be used during retrieval operations, together with Figure *3* and Figure A-1 it gives an overview of this alternative.

2.3.1 Overburden Removal

NOTE: Pass 1 will be used as a cold test of remote operations and Pass 2 will begin hot operations.

Pass 1. Moving south-to-north across the entire pit, the backhoe loads the top *3* ft of overburden (Layer A) into the soil hoppers (see Figure 16). The forklift/loader places a loaded soil hopper on an electrically powered AGV. The AGV delivers the hopper to a clean overburden area located outside the confinement structure where it is dumped by a forklift. A front-end loader then piles the soil. The forklift and front-end loader, which are only used outside the confinement structure, will be rentals or part of the INEEL equipment pool. The AGV and forklift/loader return the empty hopper to the backhoe. Pass 1 is completed before beginning Pass 2.

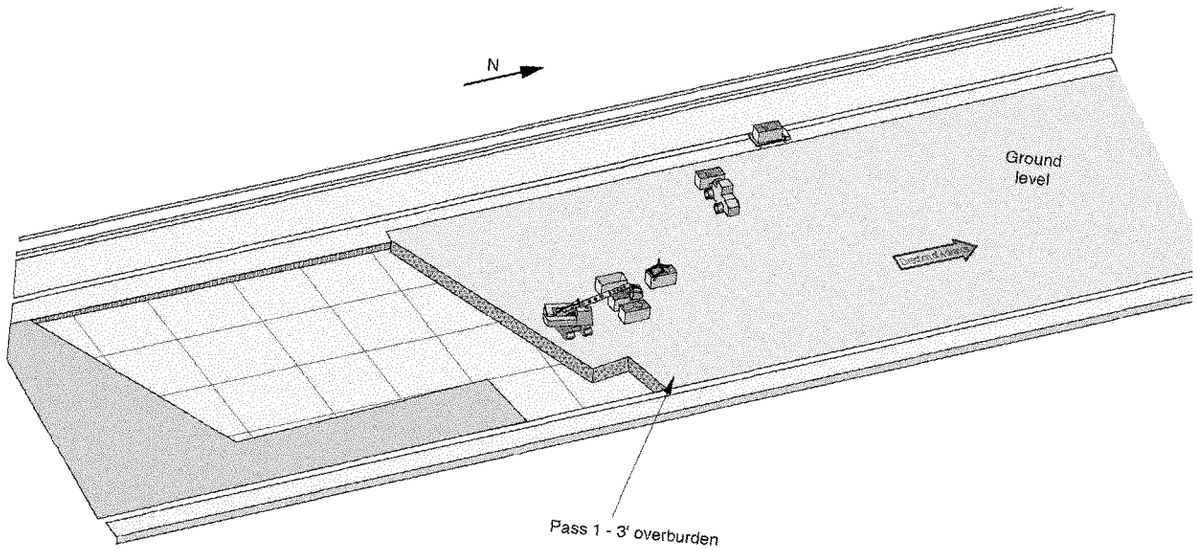


Figure 16. The backhoe and forklift/loader excavate the top 3 ft of overburden moving south-to-north.

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Pass 2. Moving south-to-north across the entire pit, the backhoe excavates and loads the next 2 ft of overburden (Layer B) into the hoppers (see Figure 17). This soil is assumed to be potentially contaminated. The forklift/loader carries each hopper directly to the inside overburden staging area, dumps it, and returns it to the backhoe to be refilled. Pass 2 must be completed before beginning P

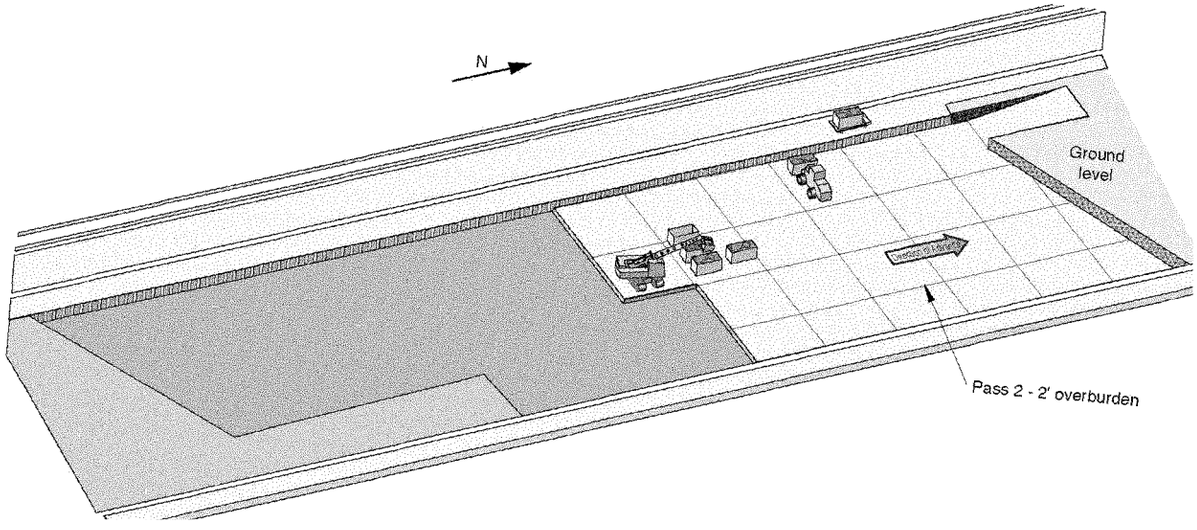

Figure 17. The backhoe and forklift/loader excavate the next 2 ft of overburden moving south-to-north.

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2.3.2 Waste Excavation

Pass 3. Moving south-to-north across the entire pit, the backhoe excavates and loads the remaining 1 ft of overburden (Layer C), 6 ft of waste material and 6 in. of underburden (Layers D and E), and 2 ft of underburden (Layer F) into the 5 x 10 x 5-ft-high boxes (see Figure 18).

The backhoe performs the following 3-part process at each working location to excavate dig face material before moving to the next working location, thereby advancing the excavation of all four layers across the pit in one pass:

Part 1. The backhoe excavates the remaining 1-ft of overburden (Layer C), segregates it from the waste, and places it in a box. All the soil between the backhoe and the dig face is excavated before starting Part 2.

Part 2. The backhoe excavates the 6-ft-thick seam of waste (Layer D) plus about 6 in. of the underburden (Layer E) and loads it into a separate box. All the material between the backhoe and the dig face is excavated before starting Part 3, except for a ledge left at the top of Layer D to keep the soil in Layer C from falling onto the underburden (Layer F). Radiation surveys are performed at the dig face to find high radiation sources. If found, this material will be placed in a separate container and grouted. High radiation objects too large for a container or any object too large for treatment will be stabilized in place or moved to a new pit location and stabilized.

Part 3. The backhoe excavates 2 ft of the underburden (Layer F) and loads it into a third box. All of the underburden between the backhoe and dig face is excavated before moving to a new work location; however, a ledge is left at the top of Layer F so that waste items from Layer D do not fall onto the exposed surface below the excavated underburden.

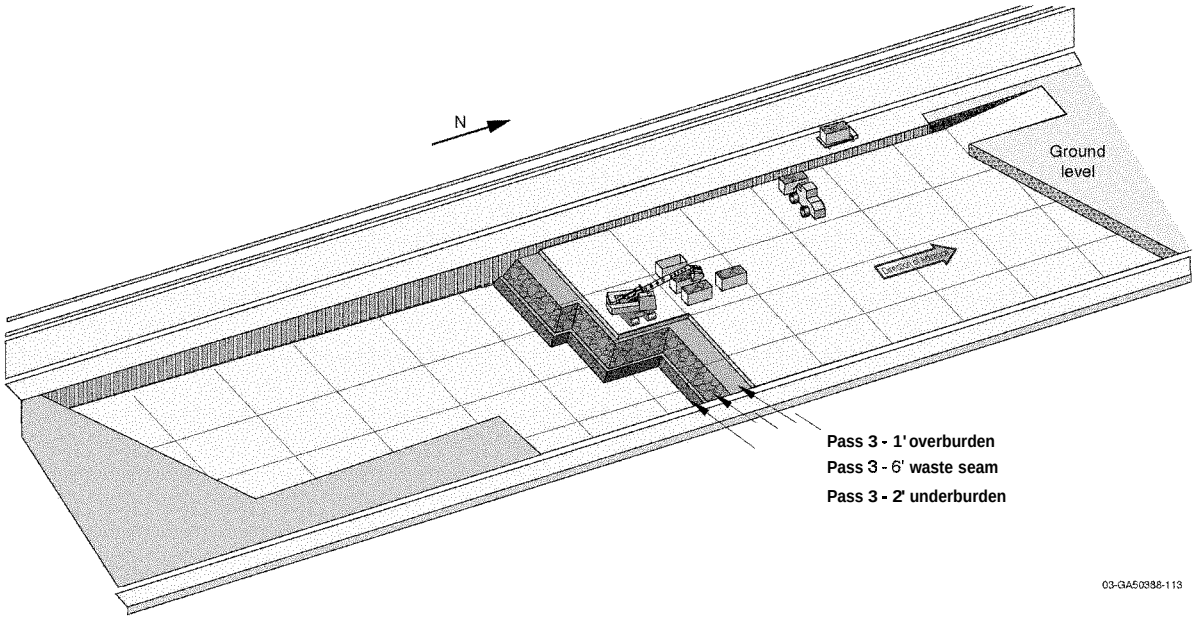

Figure 18. The backhoe and forklift/loader excavate the waste seam and underburden from the pit moving south-to-north.

When a box is full, the forklift/loader places it on the **AGV** at the north end of the pit. The **AGV** delivers the box directly to the sorting deck, where the contents are dumped, sorted, and processed through characterization. The **AGV** and forklift/loader return the empty box to the backhoe. All four layers are excavated in one work location before the backhoe is moved to the next. Excavation proceeds laterally across the pit, and advances through the dig face from south-to-north. Pass *3* will be worked in parallel with Pass 4 once enough underburden has been removed to allow Pass 4 to begin.

2.3.3 Backfill and Closure

Pass 4. Pass 4 will begin when enough underburden has been removed in Pass *3* to avoid conflicts with excavation. Moving from south-to-north, the pit is backfilled with 2 ft of the potentially contaminated soil (Layer **G)** from the inside overburden staging area, and 6 in. of gravel (Layer H) (see Figure 19); Layer **G** is composed of soil from Layer B (see Figure *3)*. The backhoe loads the soil into the hopper. The north-end forklift/loader places the hopper on the **AGV.** The **AGV** carries the hopper along the west side of the pit to the backfill area. The south-end forklift/loader removes the hopper from the **AGV** and dumps the soil on the excavated floor, spreads it, and compacts it at a depth of 2-ft. When the underburden is compacted, a 6-in.-thick layer of gravel (Layer H) is placed over the new underburden. The gravel is loaded into the hopper through an airlock chute that penetrates the containment. The forklift/loader carries the hopper across the pit, dumps it where needed, levels it, and compacts it. Pass 5 begins when enough of the graveled floor has been compacted to allow placement of the returned waste boxes without interfering with Passes *3* and 4.

The south-end forklift/loader travels on top of placed boxes to place the next row of boxes. **A** ramp is required at the south end of the pit for the south-end forklift/loader to finish the floor in Pass 4 and place the boxes in Pass 5.

Pass 5. Moving from south-to-north, the **AGV** and south-end forklift/loader backfill the pit with 5 x 5 x 6-ft-high waste boxes (Layer I) filled with repackaged and grouted waste from treatment (see Figure 19). This pass is performed in parallel with Passes *3* and 4. The **AGV** delivers the waste boxes from the treatment area to the west side of the pit. The south-end forklift/loader places the boxes on top of the finished gravel floor. Pass 5 must be completed before beginning Pass 6. The containment building and equipment may also be decontaminated at this time to minimize contamination of newly placed overburden layers.

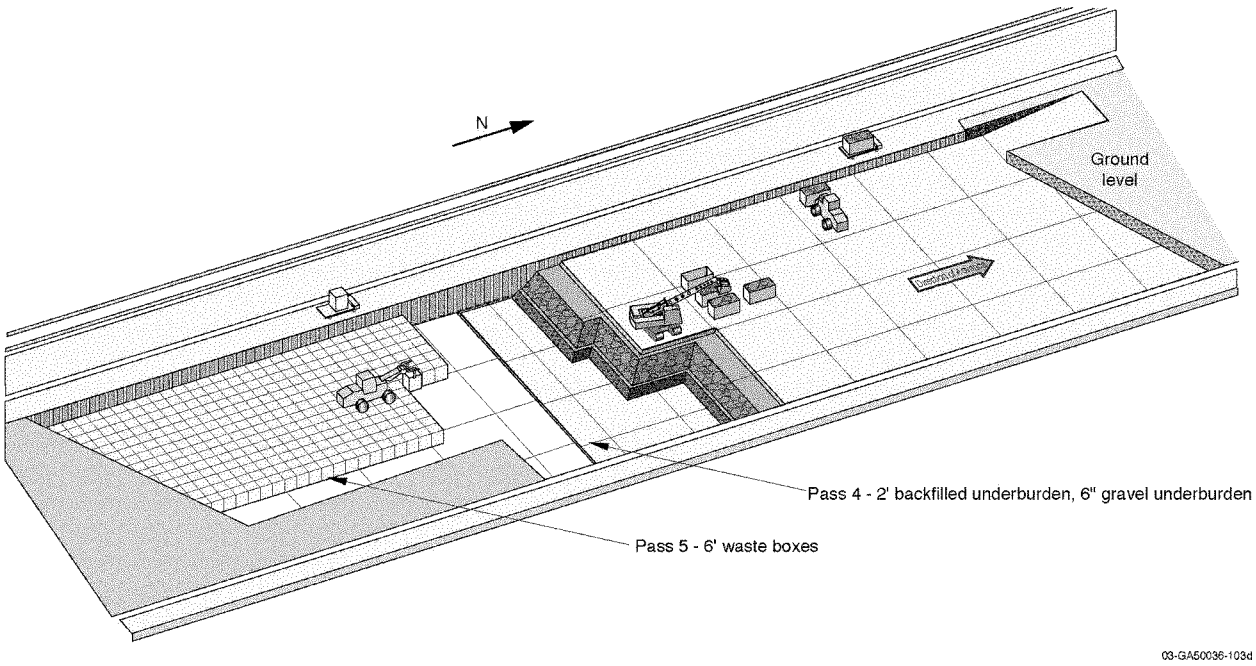

Figure 19. The backhoe and forklift/loaders backfill the pit with 2 ft of underburden, 6 in. of gravel underburden, and waste boxes moving south-to-north.

Pass 6. Using a yet to be defined sequence of operation, the hoppers, AGV, and forklift/loader backfill over the boxes with a 2-ft-thick layer (Layer J) (see Figure 20). The forklift/loader is used to level and compact the soil. Pass 6 must be completed before beginning Pass 7.

Pass 7. Using a yet to be defined sequence of operation, the hopper, AGV, and forklift/loader backfill the entire pit with a 3-ft-thick layer (Layer K) of clean overburden brought in from the outside overburden pile (see Figure 20); Layer K is composed of soil from Layer A (see Figure 3). This soil is loaded into the hopper via a chute that enters the building through airlock doors. The AGV delivers the hopper to the backfill area where the forklift/loader dumps it, and levels and compacts the soil. This operation may be done in 8-in.-thick intervals with building and equipment decontamination at each interval to promote successively cleaner levels of overburden. Pass 7 must be completed before beginning Pass 8.

Pass 8. After confinement building decontamination or disassembly, a clean front-end loader backfills the pit with 2 ft of clean soil (Layer L) obtained from outside the pit area (see Figure 20). This brings the finished elevation to 1 ft above the original grade. Pass 8 completes backfill and closure operations for the Backhoe-Forklift Method.

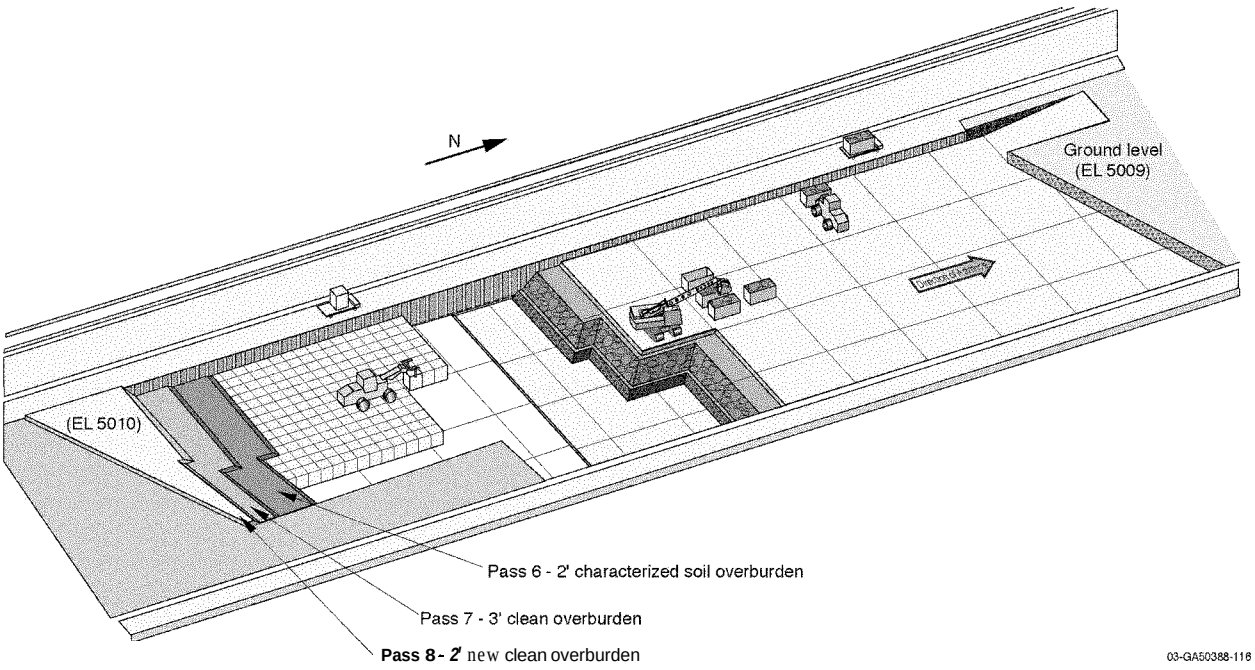

Figure 20. The AGV and forklift/loader backfill the pit with 2 ft of overburden, 3 ft of clean overburden, and 2 ft of new overburden.

2.4 Mechanical

2.4.1 Alternative 1 – Backhoe/Crane Retrieval Equipment

Overhead Crane. There are two identical overhead cranes in this alternative; either one can perform the transport or utility hnctions. The transport crane will move soil hoppers full of excavated overburden to the staging piles, boxes of excavated soil and waste to an AGV, boxes of returned waste back to the pit, and hoppers full of backfill soil to the pit. The utility crane will deploy the utility module, the decontamination module, and the grout module. One crane will be designated as the primary transport crane, the other as the primary utility crane and backup transport crane. If needed, the cranes can change assignments.

Each crane is a remotely controlled, electrically powered, 15-ton capacity, under-hung, double-girder crane with two 7-1/2-ton hoists on the trolley. The total length of the bridge is 150 ft, consisting of four 37-1/2 ft spans supported by five rails. The rails are attached to the building roof trusses. The preconceptual design of the crane was done by Progressive Crane of Cleveland, Ohio, drawing numbers P-042803 and P-042903-B (see Appendix C). Each crane will have a grapple mechanism attached to the crane hooks to handle all designated loads (soil hoppers, retrieval boxes, utility module, decontamination module, grout module, and waste return boxes). Power for the modules will also be supplied through the crane connection. Power for the soil hopper may be supplied through this same crane connection.

Backhoe. There are two identical backhoes in this alternative, but one is strictly for backup and will remain outside the containment unless needed. The inside backhoe will perform all the excavation inside the containment building. It will excavate the overburden, waste, and underburden, load the staged

overburden from the inside pile back into soil hoppers to be returned to the pit, and perform any other excavation activities required during operation.

The backhoe is a model XL-5200 manufactured by the Gradall Company of New Philadelphia, Ohio (see Appendix C). It is a diesel powered hydraulic excavator with a telescoping boom on a crawler type undercarriage. The telescoping boom design requires less head room than a standard boom and stick design plus gives the added hnction of boom rotation. Additional tools for this machine may be specified or designed during conceptual design phase, but one anticipated is a 48-in. excavating bucket with an opposable thumb and a plate tamper. The excavating bucket has a 0.96 m^3 (1.25 yd^3) capacity. The XL-5200 is available from the factory with remote controls. Other factory-installed alternatives on this machine are:

- Wide tracks to reduce ground pressure to 6.2 psi
- Opposable bucket thumb
- Engine exhaust scrubber
- Telestick to increase boom reach
- Automatic fire suppression in the engine compartment
- Synthetic fire resistant hydraulic fluid
- High reliability hoses.

Other modifications added by the dealer or secondary vendor include:

- Automatic lube system (Lincoln Industrial)
- Multiple air, oil, and hydraulic filters for extended service intervals and/or cartridge type of filter assemblies that can be replaced remotely
- Remote connect fittings for fuel filling
- Cameras for remote vision
- Radiation sensors for detecting high radiation objects
- Speed and height limitations on boom movement
- Additional end effectors such as a shear for cutting cables or a chisel for breaking concrete.

Vendor data for the backhoe, exhaust filter, auto lube system, and plate tampers are included in Appendix C.

Automatic Guided Vehicle. There are two AGVs in this alternative. A photograph of a typical AGV is shown in Figure 21. Their hnction is to transport the soil hoppers or retrieval boxes to points beyond the travel of the overhead crane and return the empty hoppers or boxes to the crane. An AGV will access the pit at the northwest corner where the crane can interface with it. Two primary destinations are the outside pile for the top overburden, and the sorting deck for waste and soil that will be processed through treatment. Secondary hnctions such as using an AGV to handle the decontamination module may also be determined as the project develops. One AGV will normally be used with the second one as a backup.

The load capacity of the AGV is 15 tons, and its ground pressure loading is too high to operate on soil, gravel, or asphalt pavement. Therefore, all routes for the AGV require concrete placement. Three companies that manufacture AGVs have been contacted and they all have similar capabilities. They are FMC Technologies (Chalfont, PA); AGV Products (Charlotte, NC); and Control Engineering Company (Harbor Springs, MI). The vehicles are electrically powered and require daily battery charging. Automatic parking to mate the vehicle with electrical power terminals is a standard feature for the vehicles. The versatile control system uses a rotating onboard laser with sensors that detect reflections from mirrors placed in the facility. This system monitors and controls the vehicle position at all times and can be used to send the vehicle to multiple locations which can be reprogrammed as operational needs change.

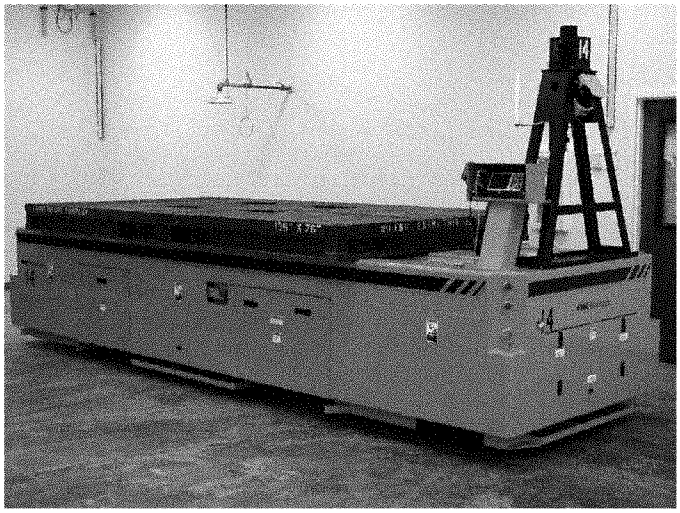

Figure 21. Automatic guided vehicle will transport soil hoppers or retrieval boxes to points beyond the travel of the overhead crane.

Compactor. There is one compactor in this alternative; the specific compactor model is a Caterpillar CP-323 with optional front blade. Its backup is the second backhoe with a plate tamper. Vendor data for CP-323 and the plate tampers are included in Appendix C. CP-323 is a vibratory compactor with a padded front drum and rear wheels. The hnction of the compactor is to level and compact the backfill in the pit and on top of the returned waste boxes as the overhead crane dumps it from the hoppers. The CP-323 is a diesel powered unit, but is not available from the manufacturer with controls for remote operation. Therefore, the installation of remote controls and other modifications must be made before it can be used in this application. Since this machine has relatively simple controls, this modification is straightforward and should present no high-risk design issues. This machine will also need an exhaust gas filter, synthetic fire resistant hydraulic fluid, automatic fire suppression, and high reliability hoses. These will be either ordered from the factory or installed by the distributor.

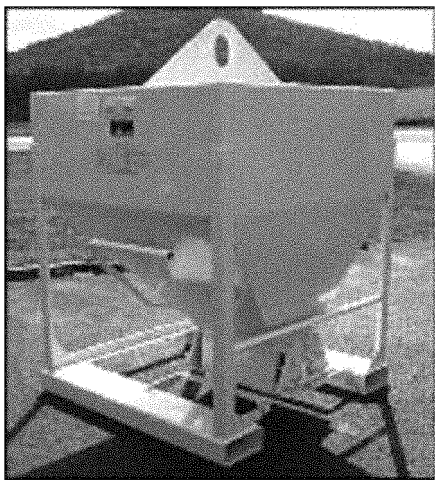

Figure 22. Soil hopper will hold Pit 9 contents during the retrieval process.

Man Lift. Two man lifts are used in this alternative; one is the primary and other is the backup. The hnction of the man lift is to transport personnel into the containment area when a manned entry must be made. The specific machine is a Grove AMZ56/XT or equivalent. Vendor data for the Grove machine is included in Appendix C. This unit is 4-wheel drive with 4-wheel steering for all-terrain capability and good maneuverability. The 3 x 8-ft work platform is mounted on a

telescoping boom and can be lowered to ground level or raised to 50 ft above ground level. If below grade access is required, a boom with additional articulation can be specified. This diesel-powered machine is not expected to require an exhaust scrubber because it will be used very little and the facility ventilation system will quickly remove the exhaust. However, this detail will be revisited in conceptual design.

Soil Hopper. Three soil hoppers are used in this alternative. The backhoe can be filling one while the other two are being transported, being emptied, or waiting to be emptied. The soil hopper design is based on a concrete bucket concept with the sidewall angle and bottom gate designed for the specific soil characteristics in Pit 9. Soil tests in conceptual design will determine this data. Gar-bro Manufacturing Company in Heber Springs, AR has been contacted to date. The photograph (see Figure 22) shows a typical concrete hopper with a crane attachment and forklift pockets. The soil hopper will be similar, with steeper sides, a larger remote actuated gate (pneumatic, hydraulic, or electric), and a crane interface compatible with the grapple that will also be used for retrieval boxes and modules.

Retrieval Box. Forty retrieval boxes are used in this alternative. The soil or waste may be temporarily staged in the extra boxes when necessary to allow the excavation process to continue. Nominal dimensions of the box are 5 ft high by 5 ft wide by 10 ft long. The boxes are designed to be handled by the overhead crane and a forklift. A preconceptual design of the boxes is included in Appendix C.

Utility Module. Two identical utility modules are used in the facility. Each is a backup for the other, but both will be used on a regular basis so that one can be available when the other is being refilled with water or other supplies. The modules can be deployed by either overhead crane, but are usually deployed by the utility crane unless it is unavailable. If the transport crane is available, it is possible to use both cranes and deploy two modules at the same time. The utility module performs various hnctions, including water spray, dust suppressant spray, fire suppressant spray, and inspection with cameras and lights. The module contains tanks for water, dust suppressant, and fire suppressant, plus the necessary nozzles, plumbing, and controls for applying them. A soil sampling probe is also included in this module for taking samples of the underburden in the pit.

Decontamination Module. Two identical decontamination modules are used in this alternative. Each is a backup for the other but both will be used on a regular basis so that one can be available when the other is being refilled with decontamination solution or other maintenance is being performed. The module can be deployed by either overhead crane, but is usually deployed by the utility crane unless it is unavailable. If the transport crane is available, it is be possible to use both cranes to deploy two modules at the same time. The decontamination module performs the hnction of spraying decontamination solution on areas to be decontaminated. This may include the facility or a piece of equipment. The spray may be a wash down solution or a strippable paint. Full details of the decontamination requirements have not yet been determined. The module contains tanks for the decontamination solution and/or the strippable paint plus the necessary nozzles, plumbing, and controls for applying them.

Grout Module. Two identical grout modules are used in this alternative. Each is a backup for the other, but both will be used on a regular basis so that one is available when the other is being refilled with grout or other maintenance is being performed. The module can be deployed by either overhead crane, but is usually deployed by the utility crane unless it is unavailable. The grout module performs the hnction of transferring grout from a grout mixing station to an object in the pit that is being grouted, such as a high radiation item or very large object that cannot be taken to the treatment facility. The module contains a tank for the grout and the necessary pump, plumbing, and controls for applying it to the object or into the container.

Remote Control Subsystems. Design of the remote control of all the equipment will be coordinated through a single vendor or a select group of vendors working together. It will include the radio transmitters and receivers, the operator consoles, the mechanical interface at the machine, and the cameras. The following vendors have extensive experience in this type of work:

- Cattron-Thiemeg of Sharpsville, PA, manufactures radio remote control equipment and has worked with Gradall and Caterpillar equipment before, in addition to several crane manufacturers.
- Cast Resource Equipment of Lively, Ontario manufactures and installs remote control interface devices on mining equipment and has used Cattron radio equipment for many applications.
- Westec Services of Richland, WA, markets the products of three companies that manufacture robotic and remote visual observation and inspection equipment. They would develop the communications for the cameras in coordination with the Cattron radio links. Cameras manufactured by Inuktun of Nanaimo, British Columbia, are specifically designed for applications such as this. Vendor data for the Inuktun Spectrum 60 is included in Appendix C.

2.4.2 Alternative 2 − Front-End Loader–Backhoe Method Retrieval Equipment

Front-End Loader. Two identical front-end loaders are used in this alternative. Both can perform the same hnctions and either one can back up the other. The loaders have interchangeable "quick connect" buckets and forks that can be changed by remote control, allowing both machines to hnction as either a loader or a forklift. The loader hnction of the machine is used to excavate and transport the overburden, waste, and underburden. In some cases, soil is excavated and piled by the backhoe; then the loader scoops the pile and transports it. The forklift hnction of the machine is used to handle the returned waste boxes.

Each loader is a remote controlled Caterpillar-Elphinstonemodel R1600 LHD (Load-Haul-Dump). Caterpillar-Elphinstoneis an Australian subsidiary of Caterpillar. The Caterpillar brochure for this machine is included in Appendix C. The interchangeable bucket and forks are provided by Weldco-Beales Manufacturing Company. Vendor information for this system is also included in Appendix C. Remote controlled LHDs have been used in underground mines for several years where overhead clearance is limited. They are designed to scoop material and haul it moderate distances. This capability is available from the factory. Installation will be coordinated with the other remote controlled equipment (backhoes) and radio communication links (cameras) so that the overall system hnctions correctly. Other factory-installed alternatives on this machine are:

- Engine exhaust scrubber
- Automatic fire suppression in the engine compartment
- Synthetic fire resistant hydraulic fluid
- High reliability hoses.

Other modifications added by the dealer or secondary vendor include:

- Automatic lube system (Lincoln Industrial)
- Multiple air, oil, and hydraulic filters for extended service intervals and/or cartridge type of filter assemblies that can be replaced remotely

- Remote connect fittings for fuel filling
- Cameras for remote vision
- Radiation sensors for detecting high radiation objects
- Speed limitations on loader movement.

Backhoe. There are two identical backhoes, and either one can backup the other. One backhoe will primarily excavate the underburden and the lower overburden where the soil must be separated from the waste items or the underlying rock. When performing this operation, the backhoe piles the excavated soil where the loader can scoop it and carry it to the staging pile or sorting deck. It may also be used to remove the soil from around waste items that will be stabilized in place. The other backhoe will primarily deploy the utility, decontamination, and grout modules, including supplying the power consumed by the modules. See the Alternative 1 description for additional information.

Man Lift. There are two man lifts in the facility; one is the primary and the other is the backup. The hnction of these man lifts is the same as for Alternative 1; see the Alternative 1 description.

Utility Module. Two identical utility modules are used in this alternative. Their hnction is the same as in Alternative 1, with one exception; they are deployed by a backhoe instead of the crane. It is possible to use both backhoes to deploy two modules at the same time, and either backhoe can deploy a module, but the backhoe that isn't being used for excavation is usually used to deploy the modules. See the Alternative 1 description for additional information about these modules.

Decontamination Module. Two identical decontamination modules are used in this alternative. Their hnction is the same as in Alternative 1, with one exception, they are deployed by a backhoe instead of the crane. It is possible to use both backhoes to deploy two modules at the same time, and either backhoe can deploy a module, but the backhoe that isn't being used for excavation is usually used to deploy the modules. See the Alternative 1 description for additional information about these modules.

Grout Module. Two identical grout modules are used in this alternative. Their hnction is the same as for Alternative 1, with one exception, they are deployed by a backhoe instead of the crane. It is possible to use both backhoes to deploy two modules at the same time, and either backhoe can deploy a module, but the backhoe that isn't being used for excavation is usually used to deploy the modules. See the Alternative 1 description for additional information about these modules.

Remote Control Subsystems. The remote control subsystems for this alternative are identical to those in Alternative 1. See the Alternative 1 description for information about the remote control subsystems.

2.4.3 Alternative 3 − Backhoe–Forklift Method Retrieval Equipment

Front-End Loader. Two identical front-end loaders are used in this alternative. These loaders have interchangeable "quick connect" buckets and forks that can be changed remotely, which allows both machines to hnction as either a loader or a forklift. Both forklift/loaders can perform the same hnctions, and either one can back up the other. The main hnction of one forklift/loader is to handle and transport the soil hoppers, retrieval boxes, and returned waste boxes. See the Alternative 2 description for additional information.

Backhoe. Two identical backhoes are used in this alternative, and either one can backup the other. The primary hnction of one backhoe is to perform all the excavation that takes place inside the containment building. It will excavate the overburden, waste, and underburden, load the staged overburden from the inside staged pile into soil hoppers for return to the pit, and perform any other excavation activities required during operation. The primary hnction of the other backhoe is to deploy the utility, decontamination, and grout modules; this includes supplying the power consumed by the modules. See the Alternative 1 description for additional information.

Automatic Guided Vehicle. Two AGVs are used in this alternative. Their hnction is identical to Alternative 1, with one exception, the AGVs travel down the west side of the pit. See the Alternative 1 description for additional information.

Man Lift. Two man lifts are used in this alternative; one is the primary and other is the backup. Their hnction is the same as for Alternative 1. See the Alternative 1 description.

Soil Hopper. Three soil hoppers are used in this alternative. Their hnction is the same as for Alternative 1, except the hoppers are handled by the forklift/loader rather than the overhead crane. See the Alternative 1 description for additional information.

Retrieval Box. Forty retrieval boxes are used in this alternative. Their hnction is the same as in Alternative 1. See the Alternative 1 description.

Utility Module. Two identical utility modules are used in this alternative. Their hnction is the same as in Alternative 1, except, they are deployed by a backhoe instead of the crane. See the Alternative 1 description for additional information about these modules.

Decontamination Module. Two identical decontamination modules are used in this alternative. Their hnction is the same as in Alternative 1, except they are deployed by a backhoe instead of the crane. The modules can be deployed by either backhoe, but are usually deployed by the second backhoe unless it is unavailable. See the Alternative 1 description for additional information about the module.

Grout Module. Two identical grout modules are used in this alternative. Their hnction is the same as for Alternative 1, except they are deployed by a backhoe instead of the crane. See the Alternative 1 description for additional information about the module.

Remote Control Subsystems. The remote control subsystems for this alternative are similar to those in Alternative 1. See the Alternative 1 description for information about the remote control subsystems.